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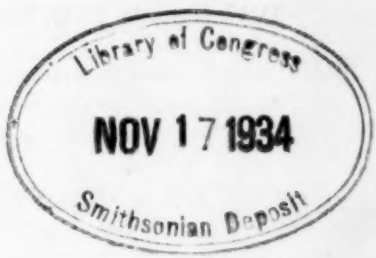

PROGRAM

FOR THE

ST. LOUIS MEETING

NOVEMBER 30–DECEMBER 1, 1934

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
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The American Physical Society

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ST. LOUIS MEETING, NOVEMBER 30–DECEMBER 1, 1934

THE 194th meeting of the American Physical Society will be held at Washington University, St. Louis, Missouri, on Friday, November 30th, and Saturday, December 1st, 1934.

This meeting marks the opening of the new Wayman Crow Hall of Physics. On Friday morning at ten o'clock short addresses will be given by Chancellor George R. Throop on "Wayman Crow" (founder of the University), and by Professor A. L. Hughes on "Physics at Washington University." On Saturday morning there will be a symposium on "X-Ray Scattering." The speakers on this symposium will be Professors G. E. M. Jauncey and E. O. Wollan of Washington University, Professor G. W. Stewart of the State University of Iowa, and Professor W. H. Zachariasen of the University of Chicago.

Luncheon. The University invites the members of the Physical Society to be its guests at luncheon on Friday, November 30th at twelve-thirty o'clock in McMillan Hall.

On Saturday, December 1st, luncheon can be had at the usual rates at the cafeteria in the Women's Building between twelve-thirty and two o'clock.

Dinner. On Friday evening at seven o'clock there will be a dinner for the members of the American Physical Society and their friends at the Hotel Chase, Lindell Boulevard at Forest Park. The price of this dinner is $1.50 per plate. Tickets should be purchased at the Physics Laboratories on Friday morning.

GENERAL INFORMATION

Headquarters. The headquarters hotel is the Hotel Chase, Lindell Boulevard at Forest Park, where the rate is $2.50 a day. Members are urged to make their reservations at once (writing directly to the hotel).

Transportation in St. Louis. From the Union Station to the Hotel Chase, the "University" car is the best, but it means about two blocks walk at each end. The taxi rate is approximately 85¢ for a taxi-load (one to five persons). From the Hotel Chase, to the University, take the "University" car or the "Lindell" bus. The taxi rate is again approximately equal to 85¢ for a taxi-load.

There are ample parking spaces on the University Campus, the main one being about 150 yards from the physics building.

Railroad Rates. The Society has made no arrangements for special rates to this meeting. Members should get in touch with their local ticket agents regarding possible reduced Thanksgiving rates.

GENERAL RULES RELATING TO PAPERS

Only those titles of papers shall be listed on the preliminary program of a meeting of the Society for which abstracts ready for publication are in the hands of the Secretary.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program. (A paper presented by two or more authors is assigned to the first named author.) Papers received after the program has been printed will be placed in the supplementary program.

All supplementary papers will be grouped according to subject matter and will be called

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for at their appropriate sessions only, these sessions to be designated on the program. The presiding officer may assign a reduced time to these papers or may in his discretion call for them to be read by title only.

Except by special vote of the Society, the maximum allowance of time for the presentation of a paper shall be ten minutes. The presiding officer shall enforce this rule.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts will be published in an early number of the *Physical Review*. Authors should send corrections to the Editorial Secretary, The American Institute of Physics Incorporated, 11 East 38th Street, New York, N. Y.

Pittsburgh Meeting. The preliminary arrangements for the Pittsburgh meeting December 27–29, 1934, include joint sessions with the American Mathematical Society (1) in a symposium on "Group Theory as Applied to Quantum Mechanics" with addresses by John von Neumann, J. H. Van Vleck, and E. P. Wigner, (2) at the delivery of the Josiah Willard Gibbs Lecture by Albert Einstein. There will be joint sessions with the Chemistry Section of the A.A.A.S. and the American Association of Physics Teachers in an all day symposium on "Heavy Hydrogen and Its Compounds." The speakers on the physical aspects will be G. H. Dieke, R. C. Gibbs, Otto Stern, and M. A. Tuve; on the chemical aspects F. G. Brickwedde and H. L. Johnston. There will also be a joint session with Section B of the A.A.A.S. at which time the Retiring Vice-President of Section B, C. J. Davisson, will deliver an address on "Electron Optics." There will be another address by an officer of the Physical Society. The Physical Society will join with the American Association of Physics Teachers in a trip to the Gulf Research Laboratories on Thursday evening. The dinner will be held on Friday evening. On Saturday afternoon the Physical Society will join with the Acoustical Society in a program where the speakers will be Hallowell Davis, Vern O. Knudsen and E. C. Wente.

Webster Hall at Fifth Avenue and Dithridge Street has been selected for hotel headquarters for the American Physical Society at Pittsburgh. The rates per day will be: with bath, single rooms, $2.50 to $3.00; double rooms, $3.50; without bath, single rooms, $2.00; double rooms, $3.00. Members are urged to make their reservations at once (writing directly to the hotel).

Other meetings for the current season are as follows:

195. Los Angeles, California. Pacific Coast Section. December 21–22, 1934.
196. Pittsburgh, Pennsylvania. Annual Meeting. December 27–29, 1934.
197. February, 1935. New York City.
198. April, 1935. Washington, D. C.

W. L. SEVERINGHAUS, *Secretary*
Columbia University, New York, N. Y.

November 10, 1934.

CALENDAR

Friday Morning

10:00 o'clock: Physics Hall: Room 101: Addresses by Chancellor Throop and Professor A. L. Hughes: Papers No. 3–8. See pages 5–6.

Friday Afternoon

2:30 o'clock: Physics Hall: Room 104: Papers 9–17. See pages 6–8.

2:30 o'clock: Physics Hall: Room 101: Papers 18–25. See pages 8–9.

4:00 o'clock: Physics Hall: Conference Room: Meeting of the Council.

Friday Evening

7:00 o'clock: Dinner: Hotel Chase.

Saturday Morning

10:00 o'clock: Physics Hall: Room 101: Symposium on X-Ray Scattering. Papers 26–29. See pages 9–10.

Saturday Afternoon

2:00 o'clock: Physics Hall: Room 101: Papers 30–36. See pages 10–11.

PROGRAM

FRIDAY MORNING AT 10:00 O'CLOCK, PHYSICS HALL, ROOM 101

1. Wayman Crow, Founder of Washington University

CHANCELLOR GEORGE R. THROOP

2. Physics at Washington University

PROFESSOR A. L. HUGHES

3. The Formation of a Potassium Film on Silver. JAMES J. BRADY, *St. Louis University.*—Photoelectric studies were made of potassium films deposited on a freshly evaporated silver surface. The photoelectric cell was of the concentric sphere type used in the study of the energy distribution of photoelectrons. Current-voltage curves were obtained with particular attention being given to the study of the saturation of the photocurrent. It was previously reported (Phys. Rev. **41**, 613 (1932)), that films deposited on a surface at room temperature did not yield a constant photocurrent after deposition. The current decreases with time. Curves were obtained showing the way the photocurrent approaches saturation when the surface is at room temperature. A study was then made of the way these curves change with time after deposition. It was found that the photocurrent approaches saturation at lower voltages when examined immediately after deposition than after the film has been standing for some time. This change in photocurrent is much more pronounced with films less than 3 molecular layers than with thicker films. Similar studies were made with the condensing surface cooled with carbon dioxide snow. In this case the changes are much slower than at room temperature. Likewise, when the surface is cooled with liquid air the changes are very small even for the thinnest films examined. The formation of patches is suggested as a likely explanation for the phenomena.

4. Electrical Resistance of Cadmium Films. EDITH TOWNES AND DUANE ROLLER, *University of Oklahoma.*—Continued experiments with a molecular beam apparatus in which pure cadmium films were deposited on a glass plate cooled by either liquid air or solid carbon dioxide show that these films first become electrically conducting at a thickness of $2\text{–}7\times10^{-7}$ cm and have a critical thickness of $6\text{–}8\times10^{-7}$ cm. Special precautions were taken to have good contact between the film and the electrodes, lack of which probably accounts for the large critical thickness previously reported [Roller and Wooldridge, Phys. Rev. **45**, 119 (1934)]. The resistivity of cadmium at the critical thickness is about 1.5 times that of the bulk metal. The relations of these results to photoelectric phenomena in metallic films and to theories of film structure are discussed.

5. Heat Losses from a Tungsten Wire in Helium. WALTER C. MICHELS, *Bryn Mawr College,* AND GLADYS WHITE, *Duke University.*—One of the difficulties which arise in connection with the determination of the accommodation coefficient of a gas against a metal is that correction must be made for the thermal etching of the surface produced by the heat treatment necessary to clean the wire. It is possible to compute the effect of this etching by means of Taylor and Langmuir's data on thermionic emission (Phys. Rev. **44**, 423 (1933)) or by measurement of the total emissivity of the wire used. The two methods check each other satisfactorily, and indicate that a stable condition of the surface can be achieved. The heat losses from a tungsten wire in helium have been studied at room temperature and an accommodation coefficient of 0.092 has been found. When the correction has been made for etching, the value of the coefficient for a smooth, clean surface is 0.069, in good agreement with the lowest values obtained by Roberts (Proc. Roy. Soc. **A129**, 146 (1930)). There is some evidence that the value of 0.17 obtained for a rough surface by both Roberts and Michels is due to a semi-stable condition of the etched surface.

6. Proton Emission Resulting from Alpha-Ray Bombardment of Boron and Phosphorus. R. F. PATON, *University of Illinois.*—Protons emitted when boron is bombarded with α-particles from Th C′ are found to consist of at least four groups with characteristic velocities and corresponding energies. Phosphorus yields three such groups. On the assumption that the α-particles are captured by B^{10} and P^{31} leaving new nuclei of C^{13} and S^{34} respectively the characteristic energies for these groups are for boron: $Q=3.1\times10^{6}$ e.v., 0.35×10^{6} e.v., -0.78×10^{6} e.v., -1.86×10^{6} e.v.; and for phosphorus, 0, -1.47×10^{6} e.v., -2.96×10^{6} e.v. The values for boron check with those found by other observers who used polonium α-particles, three of them having been previously announced. The phosphorus groups are all new and indicate the advantage of using the higher energy α-particles to bombard the heavier nuclei. One faint group of protons with a small positive energy previously observed for phosphorus is not definitely observed here but the results do admit the possibility of this group's existence. These experiments were performed at the University of Tübingen, Germany. The protons were observed with a Geiger proportional counter and at right angles to the direction of the impinging α-particles, thus avoiding counting of protons produced by collision of α-particles with contaminating hydrogen.

7. The Study of the Electrical Characteristics of Geiger-Müller Tubes using a Cathode-Ray Oscillograph. J. F. SEARS AND G. E. READ, *Purdue University.*—Photographic records of the electrical characteristics of an air filled Geiger-Müller counter have been obtained with a Purdue cathode-ray oscillograph. The analysis of the photographs shows that the counting cycle may be divided into three portions: (1) breakdown, (2) conducting period, (3) charging

period. The initial breakdown occurs in a time shorter than 10^{-6} seconds. The charge flow in this period is a function of the tube pressure and voltage but is not dependent on the capacity and resistance in the circuit. Following the breakdown the potential across the counter drops to a constant value V somewhat below the threshold voltage of the counter. Circuit conditions affect the duration of and charge flow during the conducting period. The threshold voltage is a function of the pressure and geometrical characteristics. The length of the charging period depends upon the circuit characteristics and usually is the determining factor in the time of the counting cycle. The following recomendations for increasing the resolution of a Geiger-Müller counter follow from this analysis. Decrease the distributed capacity of the counter. Reduce the coupling capacity to about the same value as the grid capacity of the amplifier tube. In some cases it may be advisable to replace the resistance in series with the counter with a constant current device having a low capacity.

8. Apparatus for Transmitting Cosmic-Ray Data from Stratosphere. J. M. BENADE AND R. L. DOAN, *University of Chicago.*—Ionization current is measured by a specially constructed electrometer used in connection with an optical system in which a photoelectric cell is energized whenever the charge builds up to a certain point. Flow of current through the photo-cell closes a grounding relay and also the filament circuit of a short wave radio oscillator for a length of time determined by a delayed circuit breaker. While the oscillator filament is on, impulses are sent out from two magnetic vibrators whose frequencies are determined by temperature and pressure respectively. The transmitting apparatus, weighing approximately ten pounds, is suspended from a small balloon expansible to about 20 feet filled with hydrogen. The data are received on a short wave receiver feeding into an automatic recording mechanism. On a recent trial flight in which the pressure measuring device only was sent up, radio signals were received up to a height of 9½ miles, at which point it was known previously that the device would cease to function. The balloon rose to an estimated height of 17½ miles as observed in telescopes. On future flights it is planned to send up the entire apparatus.

FRIDAY AFTERNOON AT 2:30 O'CLOCK, PHYSICS HALL, ROOM 104

Paper No. 9 will be read by title.

9. Spectrographic Determination of Calcium in Plant Ashes. KATHARINE WAY AND JOHN M. ARTHUR, *Boyce Thompson Institute for Plant Research.* (*Introduced by A. E. Ruark.*)—Standard solutions of nitrates containing 1.75% Sr, Ca in amounts from 0.266% to 0.533%, and other elements in approximately the proportionate amounts found in the ashes under consideration are prepared. Amounts of Sr necessary to make the concentration 1.75% are added to nitrated solutions of plant ashes from which Cl and SO_4 have been removed. 0.05 cc of solution is dried under controlled conditions on the lower electrode of a graphite arc. The arc, placed 55 in. from the slit of a Hilger E3 quartz spectrograph without intervening condensing lens, is run at 6 to 4 amps. on 125 volt d.c. mains. Spectra of several standard and ash solutions are taken on each plate and the differences in blackening of the lines 5330A Sr and 5350A Ca in each spectrum are determined with a photoelectric microphotometer whose construction is estimated from a curve made by plotting differences in blackening of the above pair against % Ca, for the standards. Only blackenings which fall on the straight line portion of the characteristic curve of the Cramer Spectrum Process plates employed, are used. Mean spectrographic determinations of Ca in plant ashes agree with mean chemical determinations within 5%.

10. Fluorescence of the Chlorophyll Series: The Reversible Reduction of Chlorophyll *a* and *b*. V. M. ALBERS, H. V. KNORR AND PAUL ROTHEMUND, *Kettering Foundation, Antioch College.*—Pure chlorophyll *a* was reduced in pyridine under an atmosphere of N_2 and reoxidized in air, according to the method of Pummerer (Ber. **46**, 2368 (1913)) as applied to chlorophyll by Kuhn and Winterstein (Ber. **66**, 1741 (1933)). The fluorescence spectra of the original, reduced and reoxidized chlorophyll solutions were photographed by the method previously described (Phys. Rev. **43**, 379 (1933)). Spectrograms were also obtained when the reduction took place under CO_2. The same procedure was followed for chlorophyll *b*. The reduced chlorophyll did not exhibit characteristic absorption in the visible region. The absorption spectra of the original and the reoxidized chlorophyll, in the visible region, were identical. The fluorescence spectra of the reduced and reoxidized chlorophyll are different and both are different from the original chlorophyll. The densitometer curves indicate that the fluorescence is less intense in the reduced and reoxidized chlorophyll than in the original chlorophyll. The positions of the maxima of the fluorescence bands of the original chlorophyll appear at longer wave-lengths than those in the reduced and reoxidized chlorophyll. The fluorescence spectra for both the reduced and reoxidized chlorophyll *a* and chlorophyll *b* are different when the reaction is run under CO_2 than when it is run under N_2.

11. Behavior of the Absorption Band of Uranine Solution under High Pressure. W. JAMES LYONS, *St. Louis University.* (*Introduced by F. E. Poindexter.*)—A dilute aqueous solution (83 mg per liter) of uranine, having an absorption band maximum at 4930A, was studied in the high-pressure spectrometer. Refractive indices for the three principal lines of the mercury arc, and for the wave-length corresponding to the absorption maximum were determined for pressures ranging up to 1075 kg per cm^2. Due to the

dilution of the solution no anomalous dispersion was observed. There are theoretical grounds for expecting that the absorption band maximum should shift under pressure to regions of longer wave-length. In this investigation, however, it was found that the absorption band retained its position, relative to the rest of the spectrum.

12. Raman Spectra of N_3^-, NCS^- and CO_2. A. LANGSETH, *University of Copenhagen*, AND J. RUD NIELSEN, *University of Oklahoma*.—The Raman spectra of N_3^- and NCS^- have been studied further and the results applied to determine the constitution of these ions. With prolonged exposure, the overtone $2\nu_2$ appears in the spectrum of NCS^-, although the fundamental ν_2, which is permitted by Placzek's selection rules, is absent; the implications of this peculiar result, which we previously observed in the case of N_2O [Nature **130**, 92 (1932)], are discussed. New measurements have also been made of the depolarizations and relative intensities of the principal Raman bands of CO_2.

13. Evidence from Raman Effect for a Slight Asymmetry of the Carbon Atom. R. T. DUFFORD, *University of Missouri*.—An examination of the Raman spectra of a large number of simple compounds of carbon shows widespread evidence of two slightly different strengths of bond. This paper discusses this evidence, and points out that similar but more limited evidence exists for oxygen and nitrogen. No such evidence for any elements beyond the first row of the periodic table has yet come to the attention of the writer.

14. Band Spectrum of Arsenic Oxide and Lead Oxide. E. N. SHAWHAN AND FRANK MORGAN, *Ohio State University*. (*Introduced by Alpheus W. Smith.*)—The band spectrum of arsenic oxide (AsO) has been investigated in emission and in absorption, and that of lead oxide (PbO) in absorption. The emission spectrum of arsenic oxide was obtained by passing the vapor of $AsCl_3$ into a flame or by introducing As_2O_3 into an arc. To get the absorption spectrum of arsenic oxide, light from an under-water spark was passed through the flame. In the case of lead oxide, pure PbO was vaporized in an electric furnace. Two systems of double double-headed bands have been observed in arsenic oxide. One system is degraded toward the red, the other toward the violet. A vibrational analysis of both systems has been made. In the system degraded toward the red the less refrangible heads are represented by the formula:

$$\nu = \begin{Bmatrix} 31738 \\ 31094 \end{Bmatrix} + [372(v'+\tfrac{1}{2}) - 5.5(v'+\tfrac{1}{2})^2] - [965(v''+\tfrac{1}{2}) - 5(v''+\tfrac{1}{2})^2]$$

and in the system degraded toward the violet, the more refrangible heads by the formula:

$$\nu = \begin{Bmatrix} 39861 \\ 38836 \end{Bmatrix} + [1098(v'+\tfrac{1}{2}) - 6(v'+\tfrac{1}{2})^2] - [965(v''+\tfrac{1}{2}) - 5(v''+\tfrac{1}{2})^2].$$

The *D*-system of PbO observed in emission by Bloomenthal (Phys. Rev. **35**, 34 (1930)) has been extended in absorption and a new system located which is approximately represented by the formula:

$$\nu = 30898 + [427(v'+\tfrac{1}{2}) - 1.5(v'+\tfrac{1}{2})^2] - [721(v''+\tfrac{1}{2}) - 3(v''+\tfrac{1}{2})^2].$$

15. The Band Spectrum of OH^+. F. W. LOOMIS AND W. H. BRANDT, *University of Illinois*.—Two bands at 3332 and 3565A, discovered by Rodebush and Wahl in the electrodeless discharge in pure water vapor, and two new bands at 3695 and 3893A, are shown to be, respectively, the (1,0), (0,0), (1,1) and (0,1) bands of OH^+. Rotational analysis establishes that they correspond to a $^3\Pi \rightarrow {}^3\Sigma$ transition in which the $^3\Pi$ state is inverted, with coupling intermediate between cases *a* and *b*. The lambda type doubling is large and there are exceptionally large perturbations in the 3*b*, 2*a* and 1*b* levels of the $v'=1$ state, with maxima at approximately $K'=18.5$, 14.5 and 10.5 respectively. The nine strong branches to be expected in this type of transition are found, and also enough satellite branches (nine in the 0,0 band) to determine the multiplet interyals in both states.

16. Emission Spectrum of Diatomic Arsenic. G. M. ALMY AND G. D. KINZER, *University of Illinois*.—The molecular spectrum of arsenic has been photographed in emission, using as source an end-on discharge tube into which metallic arsenic was driven from a side tube by a flame. The spectrum was greatly enhanced when the tube contained about 20 mm hydrogen. The spectrum consists of two parts, (1) an extensive group of bands between 2250A and 3750A and (2) a weak group near 4200A. Vibrational analysis of the extensive group shows it to consist of two almost completely overlapping band systems having a common lower state and similar upper states. This spectrum is evidently that obtained in absorption by Gibson and MacFarlane (Phys. Rev. **45**, 899 (1934)). The lower state, for which $\omega_e''=431.1$, $x''\omega_e''=1.15$, has been extended to $v''=45$, $G''=17{,}227$ cm^{-1}, and extrapolation gives $D_e''=27{,}500$ cm^{-1} (upper limit). The two upper states appear to be nearly coincident, with each state perturbing the other. For each state, ω_e' is about 265 cm^{-1}, and the vibrational intervals are perturbed near $v'=3$ and $v'=8$, though the displacements of the levels differ for the two states. In the stronger system no emission bands appear for values of v' from 10 to 13 although *absorption edges* do appear at the estimated positions of the heads. Bands for which $v'=14$ appear in emission.

17. Solarization at Low Intensity. A. J. REARDON AND H. P. GRIGGS, S.J., *Saint Louis University*. (*Introduced by F. E. Poindexter.*)—Experimental evidence for the existence of reversals higher than the second is put forth in this paper. The solarization curves exhibited herein were obtained by exposing continuously Extra Fast Dry Undyed Hammer photographic plates to light of low intensity (0.00012 and 0.0003 foot-candle). The results obtained show that with a total prolonged exposure of 27,652 minutes eight reversals appear in the solarization curve for each of the above intensities. The numerical value of the density of the first maximum point and the

time necessary to attain it depend upon the intensity of the light source. In the case of the lower intensity (0.00012 foot-candle) a curve containing 16 reversals is exhibited, the total exposure-time being 105,532 minutes. This curve closely resembles the damped vibration curve which is found in electricity. Another important point which is brought out is that both the density resulting from the development of the latent image and the solarization effect decrease with the aging of the emulsion. The care with which the experimentation was performed is emphasized in the explanation of a series of checks made on several possible sources of error.

Friday Afternoon at 2:30 O'clock, Physics Hall, Room 101

18. Electrostatic Pendulum. J. A. Van den Akker, *Washington University.*—Oscillation of the pendulum is maintained by electrical forces alone. A rectangular bob swings between two vertical, parallel plates placed at the center of oscillation. The pair of plates and the bob are connected to a condenser of small capacitance C, which is permanently connected to a battery or simple rectifier through a high resistance R. Thus a central force proportional to the square of the potential difference between the bob and plates acts on the bob at all times. An electrode at the base of the bob sweeps over a mercury cup or fixed electrode in passing through the center of oscillation, hence the condenser is discharged each half oscillation. If the proper time constant RC is chosen, the central force during a return swing is considerably greater than the retarding force during an outward swing. It may be shown that, for moderate amplitudes, the optimum value of the time constant is $RC=0.13T$, where T is the period of the pendulum. Other relations for sustained oscillations are given, and various modifications and applications of the pendulum are suggested.

19. The Liquefaction of Gases—A Demonstration. Charles T. Knipp, *University of Illinois.*—This paper presents two simple demonstrations on the liquefaction of gases. No new physical principles are involved. The gas to be liquefied (oxygen in the first) is placed in a 12 liter flask to which is fused a stem about 4 cm in diameter and 40 cm long, the lower end of which terminates in a Dewar flask of about 40 cc capacity. The pressure within the bulb is raised to two atmospheres and sealed off. If now the stem is submerged in liquid air the oxygen within the bulb will condense rapidly and liquid oxygen will trickle down into the Dewar. This condensation will cease in two or three minutes, resulting in about 30 cc of liquid. The thermos bottle is now removed and the Dewar containing the liquid oxygen is defrosted. The liquid oxygen thus condensed will slowly re-evaporate over a period of an hour or more. The pressure within the bulb during the cooling process will fall from about 140 cm to 40 cm of mercury. The second demonstration is to repeat the above with a duplicate container but using *dry air* instead of oxygen. The yield of liquid now is but 2 or 3 cc and comes from the oxygen content of the air which approximates the calculated volume under the conditions of the experiment. The liquids thus condensed may leisurely be studied as regards their colors and magnetic properties.

20. Elastic Scattering of Electrons in Argon, Krypton and Hydrogen. G. M. Webb, *Washington University.*—The distribution-in-angle of electrons scattered elastically in A, Kr and H_2 has been determined over the angular range 10°–150° for primary electron energies of 25 to 900 volts. In argon it was found that one maximum and two minima are present up to 300 volts. From 300 to 800 volts one minimum only occurs. Two *different* maxima are exhibited in the scattering by krypton, the first being prominent from 25 to 100 volts, the second appearing at this voltage for large angles. With increasing energies the first maximum changes position progressively to smaller angles and merges with the main body of scattering at about 350 volts. There is a single maximum in the range 350 to 900 volts. In the scattering by H_2 a single minimum occurs for low energies. At higher energies (200 to 900 volts) the curves all fall monotonically with angle. The experimental results have been compared with theory. At low voltages (for A and Kr) the qualitative agreement is fairly good when Henneberg's phase shifts are used. At higher voltages (500 to 800 volts, in A; and 700 to 900 volts, in Kr) the scattering is given quite accurately by the Born approximate equation for a limited angular range (10° to 60°). In H_2, at the higher voltages, fair agreement is obtained with the theoretical scattering predicted by theory.

21. Intensity Distribution in Electron Diffraction Patterns of ZnO and Atomfactor. H. J. Yearian, *Purdue University.* (*Introduced by K. Lark-Horovitz.*)—As has been shown already (K. Lark-Horovitz and H. J. Yearian, Phys. Rev. **42**, 905 (1932)) the intensity of electron diffraction rings of ZnO differs markedly from the intensity of the corresponding x-ray pattern. It was pointed out previously, that this difference is due to a distortion of the electron cloud around the nucleus. Careful new measurements have made it possible to evaluate this distortion quantitatively. Instead of treating the different electron shells, as calculated by James's and Brindley's methods, as concentric, it has been assumed that the L, M, N shells are slightly displaced along the c-axis. In this way complete agreement between calculated and observed intensities has been obtained. The x-ray F-curves are not influenced by this distortion and the calculated values agree with the experimental results.

22. A Mathematical Modulus Derived from X-Ray Data for Evaluation of Residual Distortion in Crystals. G. L. Clark and M. M. Beckwith, *University of Illinois.*—From accurate measurement of the peripheral widening of diffraction intensity maxima from a series of silicon steel specimens with a widely varying residual grain dis-

tortion or strain, it has been possible to derive a mathematical modulus which enables the numerical evaluation of this distortion in points above a basic value. Comparisons are made in terms of degree of cold work and temperature and time of heat treatment. These values are then correlated with actual measurements of magnetic permeability, and a very close parallel is established.

23. X-Ray Extinction in Piezoelectric Crystals. GERALD W. FOX AND WALTER A. FRASER, *Iowa State College.*—The original work of Fox and Carr on the effect of piezoelectric vibrations of quartz crystals on the Laue patterns has been continued and extended to include Tourmaline and Rochelle salt crystals. The effect of different surface conditions on the Laue patterns has also been studied. The results obtained for all three types of crystals were similar, all the effects being most pronounced in quartz. Quartz is undoubtedly the best material for the study of x-ray extinction in piezoelectric crystals. It was concluded that this phenomenon may be explained as the effect upon the primary and secondary extinctions due to the warping of the lattice planes in the surface during piezoelectric oscillation. More precise definitions of primary and secondary extinctions are offered.

24. A Simplification of Prins' Formula for Diffraction of X-Rays by a Perfect Crystal. FRANKLIN MILLER, JR., *University of Chicago. (Introduced by S. K. Allison.)*—The intensity formula of Prins for diffraction of x-rays from a perfect crystal has been simplified so that $F(l)$ is a real, single-valued, algebraic function of l, the deviation of the glancing angle from the corrected Bragg angle. By neglecting absorption in the crystal Darwin's formula is obtained in a new form. By differentiation the maximum ordinate of the diffraction pattern is obtained. To calculate percent reflection (i.e., maximum ordinate of the rocking curve of a double crystal spectrometer in the $1,-1$ position) $\int_{-\infty}^{\infty} F(l)dl$ and $\int_{-\infty}^{\infty} F^2(l)dl$ are needed, and these integrals have been evaluated analytically for Darwin's case of no absorption, leading to a value of $4/5$ for P_0. To include absorption $F(l)$ has been expanded into a series in powers of β/δ and an approximate formula taking account of polarization has been obtained for P_0 in terms of the constants of the crystal. This formula agrees with the graphically determined values of P_0 to within a few percent.

25. The Structure of Liquid Methyl Alcohol. W. H. ZACHARIASEN, *University of Chicago.*—By use of the method developed by Warren and Gingrich (Phys. Rev. **46**, 369 (1934)) Fourier integral analyses of the liquid x-ray diffraction patterns of alcohols have been made. Stewart and Morrow's experimental data (Phys. Rev. **30**, 232 (1927)) were used. The radial atom distribution found for the long chain alcohols completely confirms the structure model recently proposed by Warren (Phys. Rev. **44**, 969 (1933)). On the basis of the atom distribution curve found for methyl alcohol the structure of the liquid is derived. It is found that the oxygen atom of one molecule is linked to the oxygen atoms of two neighboring molecules through hydrogen binding. The hydrogen atom of the hydroxyl group thus is lying in between two oxygen atoms, although probably nearer to one than to the other. This type of hydrogen binding is responsible for the glass forming tendency of the alcohols.

SATURDAY MORNING AT 10:00 O'CLOCK, PHYSICS HALL, ROOM 101

SYMPOSIUM ON X-RAY SCATTERING

Invited Papers

26. The Structure of Radicals in Crystals. W. H. ZACHARIASEN, *University of Chicago.*—During the last years a great number of crystal structure investigations have been made with the object of determining the shape and dimensions of radicals. The results of this extensive and systematic work will be presented in comprehensive form, and discussed in connection with theories of the chemical bond. Especially the oxygenic radicals of boron, carbon, nitrogen, phosphorus, sulphur and chlorine will be taken up for consideration. (25 minutes.)

27. Diffuse Scattering of X-Rays by Crystals. G. E. M. JAUNCEY, *Washington University.*—Early experiments by Jauncey and May showed that Debye's theory of the diffuse scattering of x-rays from single crystals was inadequate at least for rocksalt and calcite. A much more adequate theory was worked out in 1931 by Jauncey and Harvey and independently by Woo, and a formula for S (the ratio of the actual scattered intensity to the intensity on the Thomson theory) was obtained for crystals consisting of atoms of one kind. The theory has since been extended to crystals consisting of atoms of several kinds and so as to include the extra negative term which appears in the incoherent part of S according to the Waller-Hartree quantum-mechanical theory of scattered radiation from a free atom. (This term does not appear in Wentzel's formula.) Experimental S values have been obtained by Claus, Harvey, Williams, Ehrenfest, Pennell and the writer for NaCl, KCl and NaF at various angles and various temperatures. Both monochromatic x-rays and x-rays from the continuous spectrum were used. Theoretical S curves can be calculated from James and Brindley's quantum-mechanical f and E_r values. The most recent experimental S values for KCl agree remarkably well with the theoretical values provided that the E_r's for the various electrons are taken to be different and not all equal as was previously suggested by A. H. Compton. The best agreement for NaF is obtained when the Waller-Hartree negative term is included in the theoretical formula. (25 minutes.)

28. The Study of the Nature of Liquids by Means of X-Ray Diffraction. G. W. STEWART, *State University of Iowa.*—This paper discusses the limitations and attainments in the x-ray diffraction study of liquids, and the usefulness of present and prospective results. (25 minutes.)

29. The Scattering of X-Rays by Gases. E. O. WOLLAN, *Washington University.*—The intensity of scattering of x-rays by gases was given a satisfactory theoretical treatment only after the advent of the new quantum mechanics. Since then, however, practically identical results have been obtained on the basis of classical theory. Measurements of the total intensity of scattering of x-rays by a number of gases have been made and the results have been found to be in good accord with the predictions of the theory. For the case of monatomic gases the theory makes it possible to convert the measured intensities into the corresponding atomic structure factors to a very close approximation. The structure factors calculated in this way correspond to the atom at rest and hence the electron distribution curves derived from these data give an accurate picture of the charge distribution within the atom. A comparison of these curves with corresponding ones obtained by x-ray reflection from crystals in which case the intensity is affected by the thermal agitation of the atoms has given information regarding the existence of zero point energy for the atoms in the crystal. For a more complete test of the theory of scattering by gases, measurements have also been made on the incoherent portion of the scattered radiation which is modified in wave-length by the Compton effect. The results of these experiments are also in accord with the theory. (25 minutes.)

SATURDAY AFTERNOON AT 2:00 O'CLOCK, PHYSICS HALL, ROOM 101

30. Index of Refraction of Water and Paraffin at High Frequencies. LESTER S. SKAGGS AND R. T. DUFFORD, *University of Missouri.*—By use of a special magnetron oscillator, and an interference method, the index of refraction of water and of paraffin has been measured at wave-lengths of approximately 10 cm, extending the observations about 2.5 octaves above any values known to the authors to have been previously reported. The results are in accord with classical electromagnetic theory.

31. The Effect of Pressure on the Refractive Index of Carbon Disulfide. FRANKLIN E. POINDEXTER, *St. Louis University.*—The refractive index of CS_2 for each of the Hg arc lines, 5790A, 5460A and 4360A, was measured on a high pressure spectrometer at a series of pressures from 1 to 1880 kg per cm². It was found that the dispersion increases over the whole range of pressure, the increase being much more rapid at the lower pressures. The high pressure spectrometer is discussed with reference to sources of error and recent improvements.

A table of values obtained is given below,

Pressure	n_Y	n_G	n_B
1	1.6526	1.6556	1.6735
448	1.7005	1.7053	1.7339
824	1.7119	1.7169	1.7464
1160	1.7208	1.7259	1.7556
1530	1.7262	1.7342	1.7673
1880	1.7347	1.7396	1.7705

where pressures are in kg per cm², and n_Y, n_G and n_B are the indices of the above wave-lengths respectively.

32. On the Comparison with Experiment of the Fermi Theory of Beta-Ray Disintegration. E. J. KONOPINSKI AND G. E. UHLENBECK, *University of Michigan.*—One can show that in the Fermi theory in most cases the nuclear charge Z has only a slight influence on the probability of emission of an electron (or positron). Putting $Z=0$, the probability of emission of an electron in the impulse range dp becomes (for the neutrino mass $\mu=0$) proportional simply to the squares of the impulses of electron and neutrino. Or one can say that the energy is divided between the electron and the neutrino according to the number of states into which the electron and the neutrino can go. This explains Sargent's law about as accurately as the more exact theory with $Z\neq 0$. It also represents rather well the dependence of the average energy on the maximum energy, which is a test on the form of the β-ray spectrum. There is, however, a systematic deviation from experiments, which is not removed either by taking $Z\neq 0$ or by introducing a neutrino mass $\mu>0$. The theoretical distribution is not asymmetric enough. Other possible reasons for this discrepancy will be discussed.

33. The Present State of the Neutrino Hypothesis. G. BECK, *University of Kansas.* (*Introduced by W. L. Severinghaus.*)—It is now generally recognized that the continuous β-spectra emitted during the radioactive β-decay have to be formally treated as a double process in which beside the emerging electron a second particle of unknown properties is emitted. If $E(Z)$ and $E(Z\pm 1)$ denote the energy of the initial and the final nucleus, W and m the energy and mass of the emitted electron, W' and m' energy and mass of the hypothetical second particle, the relation holds $E(Z)-E(Z\pm 1)=W+W' \geq (m+m')\cdot c^2$. From this equation we deduce the condition for the β-stability of a nucleus, $E(Z)-E(Z\pm 1) < (m+m')\cdot c^2$. Evidence for the validity of this condition is found in the system of known isotopes. A more detailed treatment of the β-decay requires assumptions on the formally introduced second particle. Two attempts have been made in this respect by Fermi and by Beck and Sitte. Fermi treats the second particle as a neutrino of high penetrating power and has to assume $m'=0$. Beck and Sitte connect the β-emission with the production of a pair of differently charged electrons, one of which is absorbed by the nucleus without conservation of me-

chanical integrals. Arguments are given to show that the neutrino hypothesis is not sufficient to remove the difficulties arising from the experimental evidence.

34. Discussion of Fermi's Theory of the Beta-Decay. R. L. DOLECEK, *University of Kansas.* (*Introduced by W. L. Severinghaus.*)—The shape of the continuous β-spectra and the relative decay probabilities of different types of nuclei have been determined according to Fermi's theory and are compared with the experimental data.

35. A Search for a Photomagnetic Effect. RICHARD M. EMBERSON AND R. T. DUFFORD, *University of Missouri.*—The magnetic susceptibilities of more than sixty substances were measured by the method of Lord Kelvin. The list of substances includes many of the Grignard solutions which give the photovoltaic effect studied extensively in this laboratory, and the primary substances from which they are made. Most of these susceptibilities have values in the neighborhood of 6×10^{-7} c.g.s. units. The equipment used could measure such values with an error of less than half of one percent. In no case was any change in susceptibility due to illumination detected. Hence, either the magnetic susceptibility is not dependent on the number of free electrons present, or else the photovoltaic effect does not involve the liberation of electrons.

36. The Surface Tension of Mercury in the Presence of Gases. I. Dry Air. MARIE KERNAGHAN, RSCJ, *Maryville Corporate College of the Saint Louis University.*—The main section of the apparatus and the method (flat-drop) are those used by the author (Phys. Rev. **37**, 990 (1931)) to find the surface tension of mercury in a vacuum. A combination of drying tubes and pressure gauge has been inserted between the surface tension chamber and the McLeod gauge. The arrangement dispenses with stopcocks and is designed to admit any gas in small quantities and to hold the pressure constant during any length of time. By means of a special attachment nitrogen can be obtained directly from the air. The apparatus has been tested by studying the effect of varying pressure in the presence of dry air. The surface tension, evaluated by application of Worthington's formula, was found to drop rapidly from 464 dynes per cm in a vacuum until an apparently critical pressure of 7 mm was reached. Values for higher pressures remained fairly constant.

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member one only of these will be assigned a place on the regular program while the others will be placed in a supplementary program to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for only at the session indicated.